NASA Renewable Energy Assessment

Summary for NASA Facilities Engineering and Real Property Conference

5/11/11

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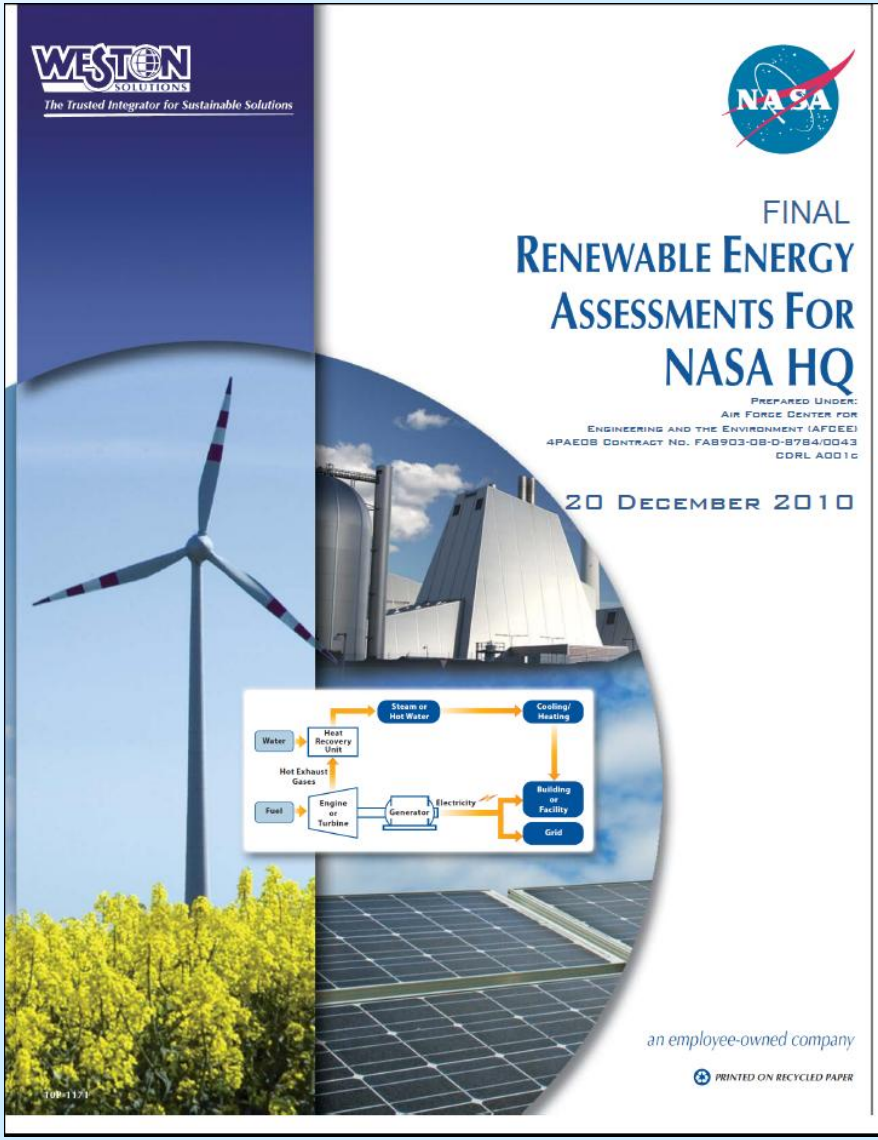
Agenda

- 1.0 Background
- 2.0 Introduction
- 3.0 Consistency
- 4.0 RETScreen Software
- 5.0 Project Metrics
- 6.0 Site Summaries
- 7.0 Summary & Ranking
- 8.0 Path Forward



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- 4.0 RETScreen Software
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- 7.0 Summary & Ranking
- 8.0 Path Forward

1.0 Background

- 1.1 History of Federal Energy Management
  - Energy Policy Act of 2005 (EPAct 2005) establishes statutory Federal renewable energy requirement and definitions
    - Percentage of total electricity from renewable sources
      - 3% FY 2007-2009
      - 5% FY 2010-2012
      - 7.5% FY 2013+
    - Double-credit bonus if energy produced on Federal or Native American land and used at Federal facility

1.0 Background

- 1.1 History of Federal Energy Mgmt. (cont'd)
  - Executive Order (EO) 13423 expands requirement
    - Half of renewable energy to fulfill statutory requirement must be from new renewable sources built after 1/1/1999
      - Thermal renewable energy counts toward new
  - Department of Energy (DOE) guidance clarifies requirement
    - http://www1.eere.energy.gov/femp/pdfs/epact05_fedrenewenergyguid.pdf
  - White House Office of Management and Budget monitors compliance via Sustainability/Energy Scorecard

1.0 Background

- 1.2 Sustainable Approach to Energy
  - Less than 1% of world's annual energy use from renewable sources
- 1.3 Renewable Technologies and US Renewable Development

Table 1-1 Common Commercial Applications of Renewable Resources

	Direct Electric	Thermal to Electric	Thermal	Direct Mechanical	Comments[b]
Solar					Intermittent resource
Wind					Intermittent resource
Hydrogen[a]					
Geothermal					
Hydro-based					Can be intermittent resource
Bio-based					

  - Shaded blocks for wide commercial use

1.0 Background

- 1.3 Renewable Technologies and US Renewable Development (continued)
  - Tax-based Federal subsidies vary by technology and require private ownership (versus Federal)
    - Investment Tax Credit (ITC) 30% or 10% of installed cost
    - Production Tax Credit $0.02 or 0.01 per KiloWatthour (KWh) generated
      - First 10 years of operation
      - May opt for ITC or US Treasury equivalent cash grant
    - Accelerated (5-year) depreciation

1.0 Background

- 1.3 Renewable Technologies and US Renewable Development (continued)
  - State subsidies
    - Electricity generation Renewable Portfolio Standard (RPS) creates Renewable Energy Credits (RECs) demand
      - "Green" generation attribute, but not energy, of one MegaWatthour (MWh) electricity
      - Sold as commodity to produce additional revenue
      - Remaining energy MWh is "brown"
    - Rebates and grants

1.0 Background

- 1.4 Renewable Energy at NASA
  - 6.4% of electricity from renewable sources FY 2010
    - Purchased electricity
    - Purchased RECs
    - On-site generation

1.0 Background

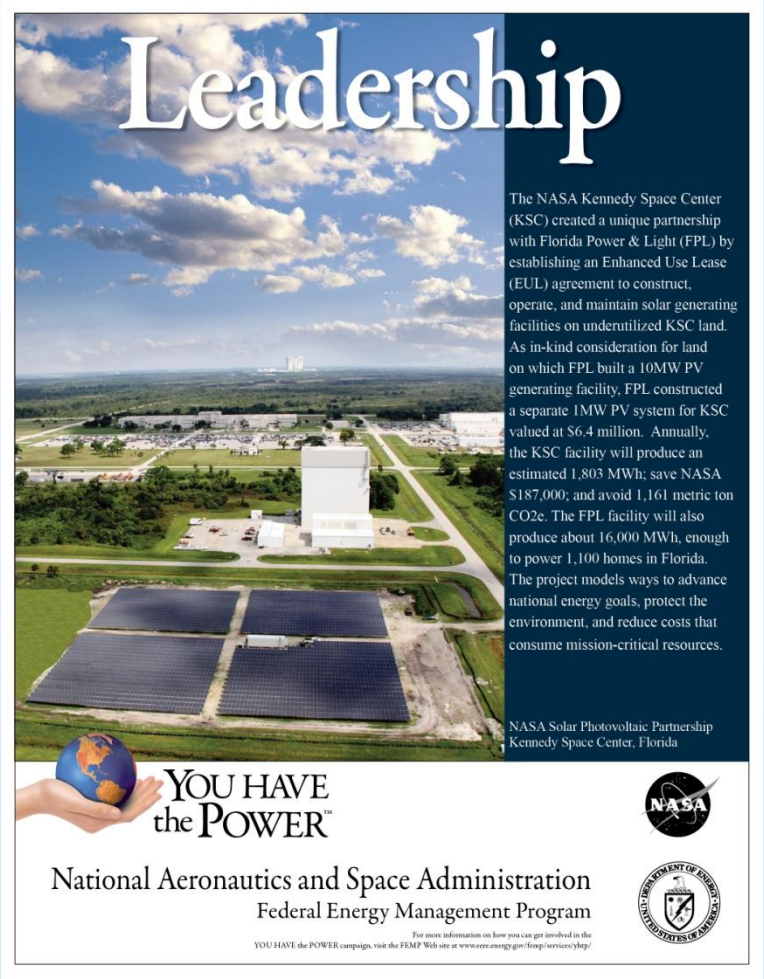
JPL-GDSCC 4 KW solar photovoltaic (PV)

1.0 Background

KSC 79 KW building integrated PV

1.0 Background

KSC 0.95 MW PV, EUL in-kind consideration

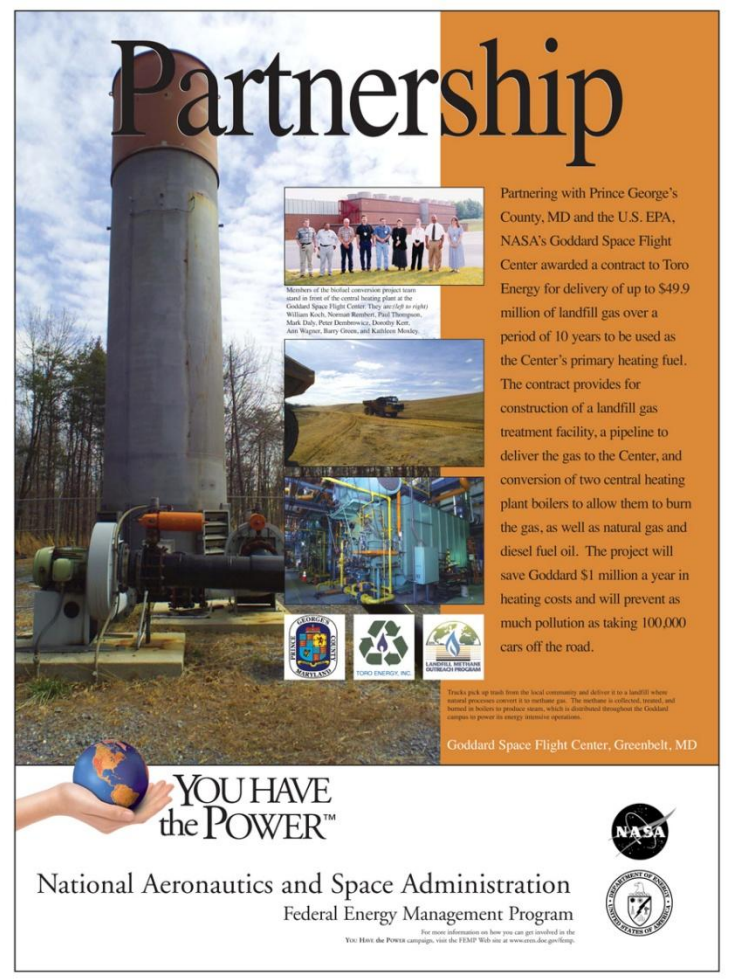


1.0 Background

- 1.4 Renewable Energy at NASA (continued)
  - Also using renewable energy that does not "count"
    - Purchased waste-to-steam
    - Purchased landfill gas (LFG) for steam
    - Solar thermal water heating
    - Wind mechanical
    - Daylighting

1.0 Background

GSFC LFG



1.0 Background

JSC 213 MBtu/yr solar thermal water heating

1.0 Background

JSC-WSTF sewage lagoon aerators

1.0 Background

JSC daylighting

1.0 Background

- 1.5 Advancing Clean and Renewable Energy at NASA
  - All NASA sites have one or more renewable resources that could be developed for energy
  - Recommend policy change because practically developable resources unequally distributed
    - Agency renewable goals should not be driven to sites
    - Direct attention to identifying and developing best projects with economic viability and clear path forward

1.0 Background

- 1.5 Advancing Clean and Renewable Energy at NASA (continued)
  - Financial barriers
    - NASA Enhanced Use Lease authority lacks in-kind consideration
    - Challenging to obtain Federal tax incentives
    - Federal agencies must replace sold RECs in order to "count" toward Federal renewable energy requirement
      - REC swap

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2.0 Introduction

2.1 Reason for the Project

- Need approach to prioritizing investment and leveraging potential funding mechanisms
  - Agency-wide assessment that seeks to identify financially viable renewable projects
  - Prefeasibility screening with consistent comparison
  - Address financial tools to capture incentives

2.0 Introduction

- 2.2 Guidance for Developing Project Approach
  - Identify most economically viable projects
  - Projects must have viable path to implementation
  - Employ only proven commercialized technologies
  - Consider each technology at each site; analyze 1 to 2 projects with economic viability per site
  - Apply metrics consistently
  - Consider all scales of projects including utility-scale
  - Consider opportunities for development on satellite facilities and/or in collaboration with other agencies
  - Consider potential projects already in review

2.0 Introduction

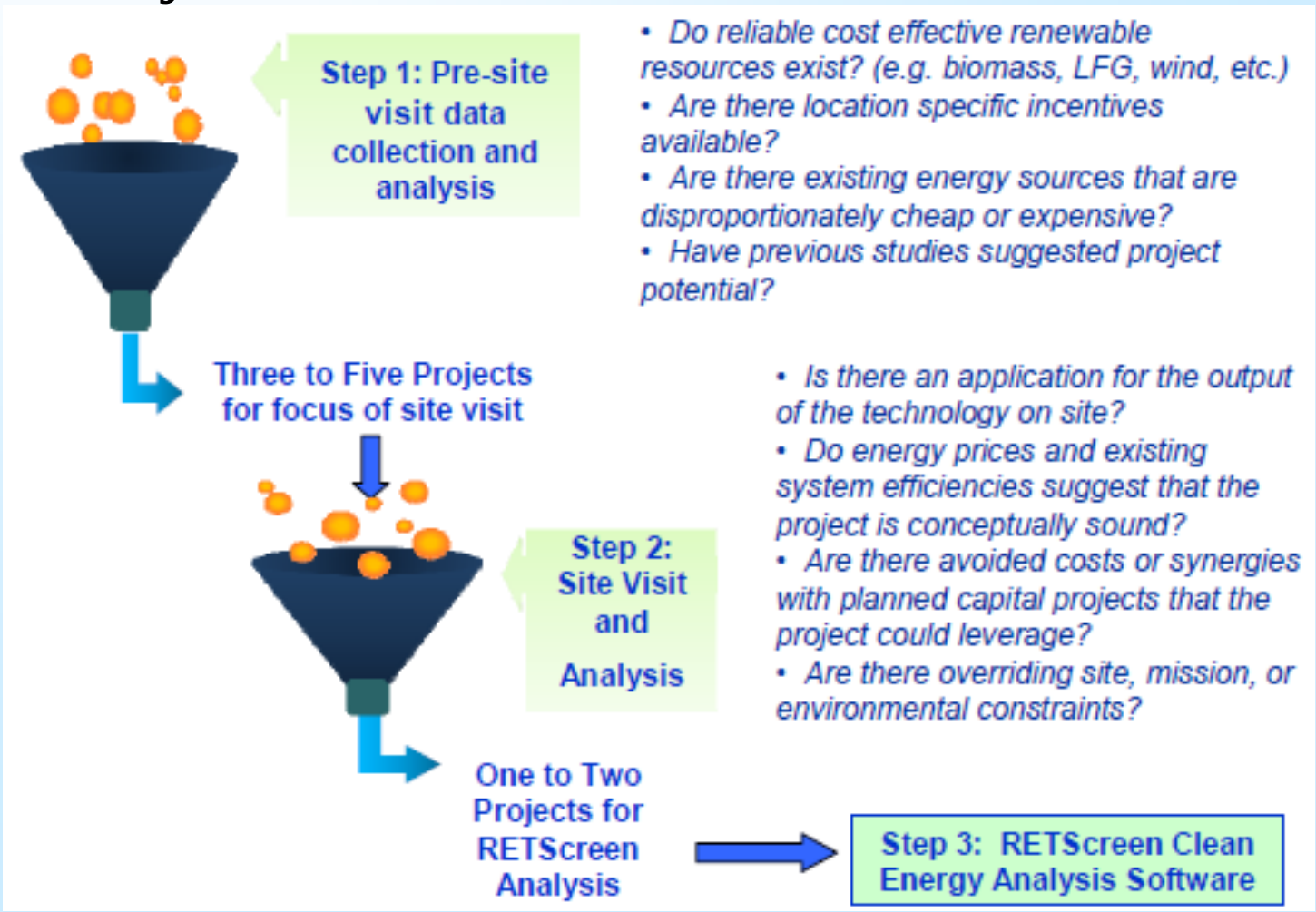
- 2.3 Technologies for Evaluation (14)
  - Wind turbines for electrical generation
  - Wind-driven mechanical power
  - Solar PV electrical generation
  - Ground source heat pumps (GSHP)
  - Biomass thermal
  - Combined heat & power (CHP) with renewable fuel
  - LFG
  - Waste to energy

2.0 Introduction

- 2.3 Technologies for Evaluation (continued)
  - Solar thermal water heating
  - Concentrating solar electrical generation
  - Biodigester gas
  - Low-impact hydro-electric generation
  - Geothermal electrical generation
  - Solar thermal air heating

2.0 Introduction

2.4 Project Structure and Execution



2.0 Introduction

- 2.5 Overview of Deliverables
  - Site meeting agenda and notes
  - Renewable energy technology pre-screening
  - Screening evaluation energy model and analysis
  - Assessment technical memoranda site reports
  - Final agency-wide report

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3.0 Consistency

- 3.0 Consistency of Assessments
- 3.1 Overview
  - Documented approach, methods, and adjustments
- 3.2 Alternative to the Proposed Project: Avoided Costs
  - Compared renewable project to status quo or required capital project

3.0 Consistency

- 3.3 Life Cycle Costing and Timing of Projects
  - Expenditures and revenues brought to present value
  - Simplified costing and discounting for prefeasibility
  - Used nominal discount rate in 10 CFR 436
  - Energy prices started with 2008 and assumed escalation rate unless better site data available
  - Implementation costs inflated to June 2009
  - Labor costs adjusted by region

3.0 Consistency

- 3.4 Project Configuration and Ownership
  - "Behind the meter" (energy used on-site) project's electricity valued at cost of avoided retail purchase
  - Utility-scale development project's electricity valued at wholesale value of generation in grid region
  - Typically assumed electricity projects as Power Purchase Agreement (PPA)
    - Private investor provides capital, owns system, sells electricity to host site per agreed price schedule, and realizes tax benefits and REC revenue
  - Assumed non-electricity projects NASA owned

3.0 Consistency

- 3.5 Renewable Energy Produced from Projects
  - For comparing electric/thermal/mechanical, converted electric into source energy using DOE national factor 11.85 MMBtu/MWh
    - Thermal equivalent of energy required to generate grid electricity
  - Assessment considered GSHP gross heating and cooling as renewable
    - Too generous
    - Not consistent with DOE reporting instructions email of incremental improvement versus 13 SEER air-to-air heat pump (see Section 5.1)

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4.0 RETScreen Software

- 4.1 Overview
  - RETScreen Clean Energy Project Analysis Software
  - Free decision support tool led by CanmetENERGY research center of Natural Resources Canada
  - Evaluates energy production, savings, cost, financial viability, and risk
  - Simplifies prefeasibility assessment through product, project, hydrology, and climate databases
  - College-level training course available

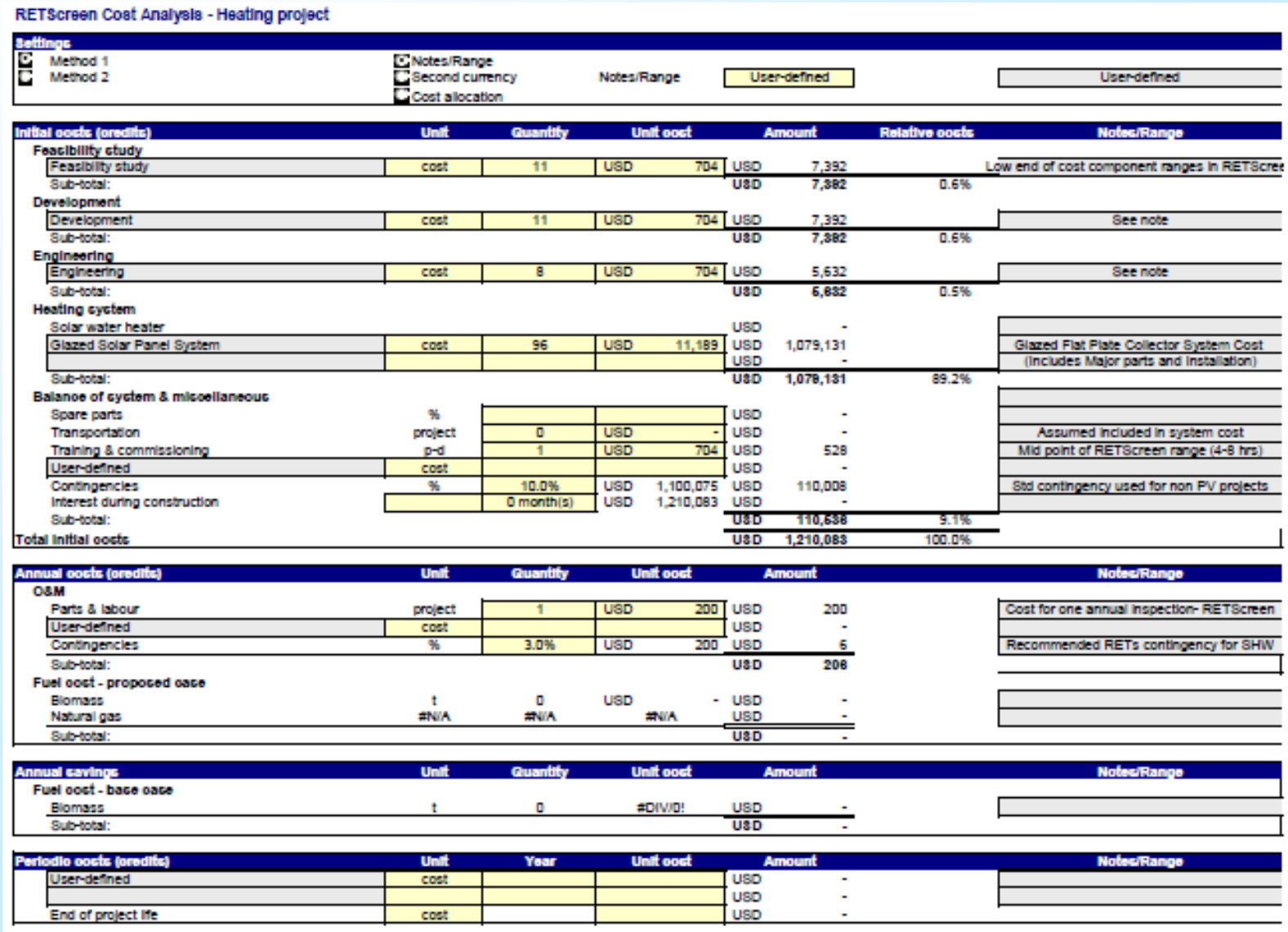
4.0 RETScreen Software

- 4.1 Overview (continued)
  - Microsoft Excel-based worksheets
    - Input
      - Start: Defines project type and location
      - Load & Network: Electricity usage and cost
      - Energy Model: Renewable technology details and energy it displaces
      - Cost Analysis: Capital and operation & maintenance (O&M)
    - Output
      - Financial Analysis
      - Risk Analysis

4.0 RETScreen Software

- 4.2 Cost Analysis
  - Used Method 1 simplified approach
  - Can reevaluate with Method 2 detailed costing
  - Costs and credits categories:
    - Initial capital feasibility through installation
    - O&M including energy from Energy Model worksheet
    - Periodic costs and credits
  - Used equipment characteristics and costs from RETScreen Product Database and RETScreen Online User Manual unless better site data available
  - Example worksheet in Appendix D-1

4.0 RETScreen Software



RETScreen Cost Analysis - Heating project

Settings

☉ Method 1	☉ Notes/Range			
○ Method 2	○ Second currency	Notes/Range	User-defined	User-defined
	○ Cost allocation			

Initial costs (credits)	Unit	Quantity	Unit cost		Amount		Relative costs	Notes/Range
Feasibility study								
Feasibility study	cost	11	USD	704	USD	7,392		Low end of cost component ranges in RETScree
Sub-total:					USD	7,392	0.6%	
Development								
Development	cost	11	USD	704	USD	7,392		See note
Sub-total:					USD	7,392	0.6%	
Engineering								
Engineering	cost	8	USD	704	USD	5,632		See note
Sub-total:					USD	5,632	0.5%	
Heating system								
Solar water heater					USD	-		
Glazed Solar Panel System	cost	96	USD	11,189	USD	1,079,131		Glazed Flat Plate Collector System Cost
					USD	-		(Includes Major parts and installation)
Sub-total:					USD	1,079,131	89.2%	
Balance of system & miscellaneous								
Spare parts	%				USD	-		
Transportation	project	0	USD	-	USD	-		Assumed included in system cost
Training & commissioning	p-d	1	USD	704	USD	528		Mid point of RETScreen range (4-8 hrs)
User-defined	cost				USD	-		
Contingencies	%	10.0%	USD	1,100,075	USD	110,008		Std contingency used for non PV projects
Interest during construction		0 month(s)	USD	1,210,083	USD	-		
Sub-total:					USD	110,638	9.1%	
Total initial costs					USD	1,210,083	100.0%	

Annual costs (credits)	Unit	Quantity	Unit cost		Amount		Notes/Range
O&M							
Parts & labour	project	1	USD	200	USD	200	Cost for one annual inspection- RETScreen
User-defined	cost				USD	-	
Contingencies	%	3.0%	USD	200	USD	6	Recommended RETs contingency for SHW
Sub-total:					USD	206	
Fuel cost - proposed case							
Biomass	t	0	USD	-	USD	-	
Natural gas	#N/A	#N/A		#N/A	USD	-	
Sub-total:					USD	-	

Annual savings	Unit	Quantity	Unit cost	Amount	Notes/Range
Fuel cost - base case					
Biomass	t	0	#DIV/0!	USD -	
Sub-total:				USD -	

Periodic costs (credits)	Unit	Year	Unit cost	Amount	Notes/Range
User-defined	cost			USD -	
				USD -	
End of project life	cost			USD -	

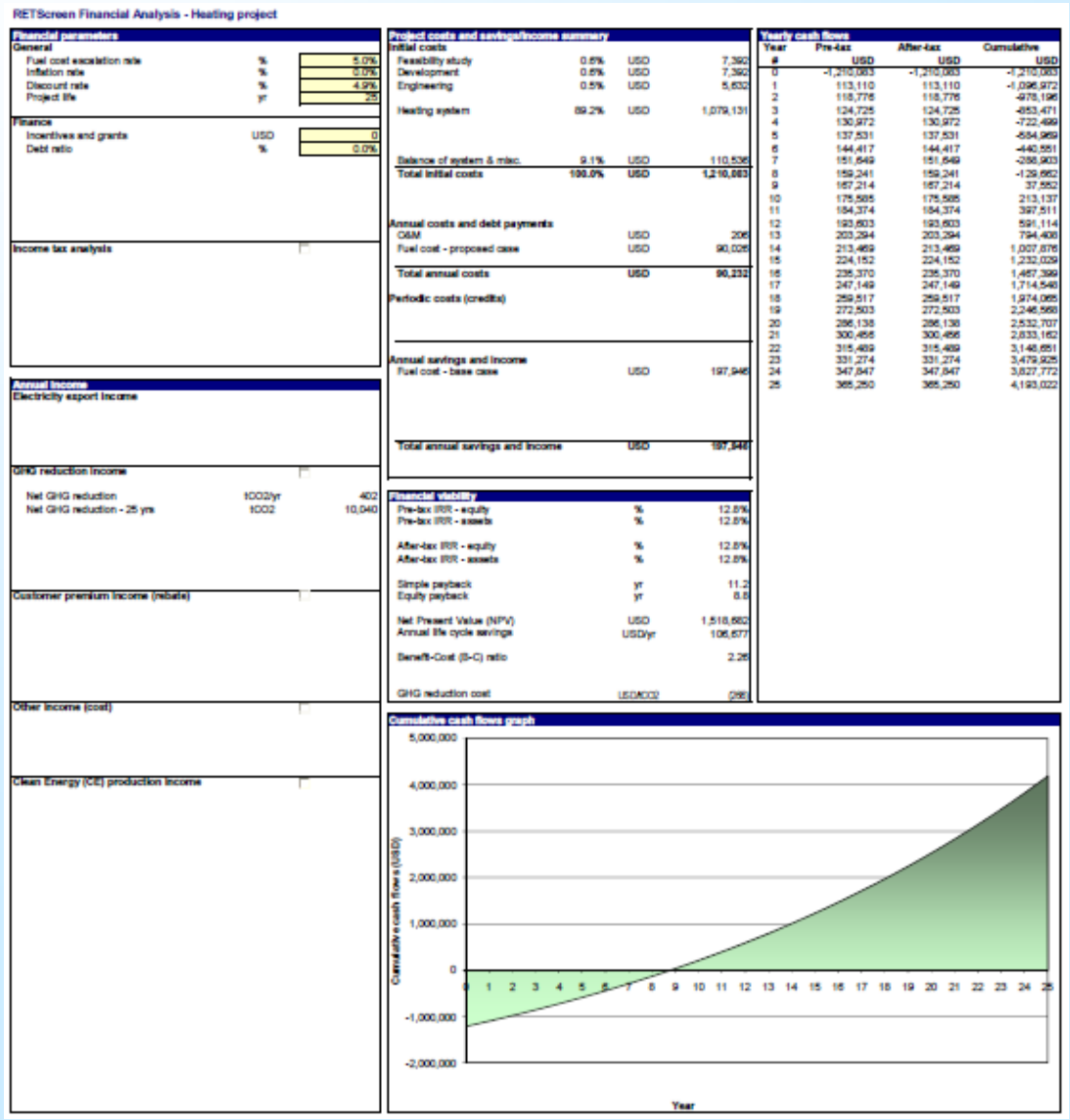
4.0 RETScreen Software

- 4.3 Financial Analysis
  - Models financial performance
  - Input financial variables
    - Used nominal discount rate 4.9% in 10 CFR 436
    - Assumed 3% energy escalation rate unless better site data
    - Project life based on life of most costly component
    - Incentives and revenue streams
      - Grants
      - Tax credits
      - Rebates
      - REC revenue

4.0 RETScreen Software

- 4.3 Financial Analysis (continued)
  - Outputs cash flows and financial measures
    - Net present value (NPV): estimated lifetime worth of annual net cash flows discounted to current dollars
    - Internal rate of return (IRR): interest rate that project returns (calculated by producing zero NPV)
    - Payback period: number of years necessary for savings to recover initial investment
    - Benefit-to-cost ratio: present value of net cash flows divided by present value of initial cost
  - Example worksheet in Appendix D-2

4.0 RETScreen Software



RETScreen Financial Analysis - Heating project

Financial parameters

General

Fuel cost escalation rate	%	5.0%
Inflation rate	%	0.0%
Discount rate	%	4.9%
Project life	yr	25

Finance

Incentives and grants	USD	0
Debt ratio	%	0.0%

Income tax analysis

Annual income

Electricity export income

GHG reduction income

Net GHG reduction	tCO2/yr	402
Net GHG reduction - 25 yrs	tCO2	10,040

Customer premium income (rebate)

Other income (cost)

Clean Energy (CE) production income

Project costs and savings/income summary

Initial costs

Feasibility study	0.5%	USD	7,392
Development	0.5%	USD	7,392
Engineering	0.5%	USD	5,632
Heating system	89.2%	USD	1,079,131
Balance of system & misc.	9.1%	USD	110,536
Total initial costs	100.0%	USD	1,210,083

Annual costs and debt payments

O&M	USD	206
Fuel cost - proposed case	USD	90,026
Total annual costs	USD	90,232

Periodic costs (credits)

Annual savings and income

Fuel cost - base case	USD	197,946
Total annual savings and income	USD	197,946

Financial viability

Pre-tax IRR - equity	%	12.8%
Pre-tax IRR - assets	%	12.8%
After-tax IRR - equity	%	12.8%
After-tax IRR - assets	%	12.8%
Simple payback	yr	11.2
Equity payback	yr	8.8
Net Present Value (NPV)	USD	1,518,682
Annual life cycle savings	USD/yr	106,577
Benefit-Cost (B-C) ratio		2.26
GHG reduction cost	USD/tCO2	(299)

Yearly cash flows

Year #	Pre-tax USD	After-tax USD	Cumulative USD
0	-1,210,083	-1,210,083	-1,210,083
1	113,110	113,110	-1,096,972
2	118,776	118,776	-978,196
3	124,725	124,725	-853,471
4	130,972	130,972	-722,499
5	137,531	137,531	-584,969
6	144,417	144,417	-440,551
7	151,649	151,649	-288,903
8	159,241	159,241	-129,662
9	167,214	167,214	37,552
10	175,585	175,585	213,137
11	184,374	184,374	397,511
12	193,603	193,603	591,114
13	203,294	203,294	794,408
14	213,459	213,459	1,007,876
15	224,152	224,152	1,232,029
16	235,370	235,370	1,467,399
17	247,149	247,149	1,714,548
18	259,517	259,517	1,974,065
19	272,503	272,503	2,246,568
20	286,138	286,138	2,532,707
21	300,456	300,456	2,833,162
22	315,469	315,469	3,148,631
23	331,274	331,274	3,479,905
24	347,847	347,847	3,827,772
25	365,250	365,250	4,193,022

Cumulative cash flows graph

4.0 RETScreen Software

4.4 Risk Analysis

- Sensitivity Analysis
  - Varied inputs within sensitivity range +/- 20 & 40%
    - Costs: Capital, fuel
    - Incentive revenue
  - Calculates impact to financial indicators
    - IRR
    - Payback
    - NPV
  - Recommend leverage tool capability to compare scenarios
  - Example worksheet in Appendix D-3

4.0 RETScreen Software

RETScreen Sensitivity and Risk Analysis - Heating project

Sensitivity analysis

Perform analysis on	Net Present Value (NPV)	
Sensitivity range	40%	
Threshold	0	USD

Fuel cost - base case		Initial costs				USD
		726,050	968,066	1,210,083	1,452,099	1,694,116
USD		-40%	-20%	0%	20%	40%
118,768	-40%	-1,463	-243,479	-485,496	-727,512	-969,529
158,357	-20%	1,000,626	758,610	516,593	274,577	32,560
197,946	0%	2,002,715	1,760,699	**1,518,682**	1,276,666	1,034,649
237,535	20%	3,004,804	2,762,788	2,520,771	2,278,755	2,036,738
277,124	40%	4,006,894	3,764,877	3,522,861	3,280,844	3,038,828

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277,124	40%	4,006,894	3,764,877	3,522,861	3,280,844	3,038,828

4.0 RETScreen Software

- 4.5 Using RETScreen to Evaluate Alternatives
  - Valuable capability to change variable, recalculate financial results, and save alternate scenario
    - System costs
    - System capacity
    - Incentives
    - Project life

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5.0 Project Metrics

- 5.0 Metrics for Evaluation of Potential Projects
- 5.1 Defining and Measuring "Renewable" Under EPAct 2005 and EO 13423
  - EPAct 2005 and DOE guidance define renewable
    - Municipal solid waste and refuse-derived fuels
    - LFG including wastewater treatment digester gas
    - Hydropower expansion/improvement of existing dams
    - Hydrokinetic "run of river"
    - Biomass
    - Geothermal
    - Solar
    - Ocean
    - Wind

5.0 Project Metrics

- 5.2 Credit Toward EPAct Goals
  - Based on electricity or non-electricity producing

Credit Score	Site Reports	Agency Report
	Credit	Credit
	Needs REC swap	did not use
	No credit	No credit

5.0 Project Metrics

- 5.3 Renewable Energy Contribution
  - Based on energy production amount

Contribution Score	Site Reports relative to site	Agency Report relative to agency
Large	≥ 5%	≥ 1%
Medium	≥ 1%, < 5%	≥ 0.01%, < 1%
Small	< 1%	< 0.01%

5.0 Project Metrics

- 5.4 Return on Investment (ROI)
  - Based on IRR

ROI Score	Value
Large	>10%
Medium	≥ 5%, ≤ 10%
Small	< 5%

5.0 Project Metrics

- 5.5 Clear Path Forward
  - Based on time period for capital recovery and barriers to implementation
    - Permitting, technology, resource, mission

Path Score	Time Period	Barriers
Clear, 1	Directly fundable, or finance ≤ 10 years	No significant issues
Intermediate, 2	Finance > 10 years and < 25 years	Issues to resolve
At Risk, 3	Finance ≥ 25 years	Major issues or air permit new source

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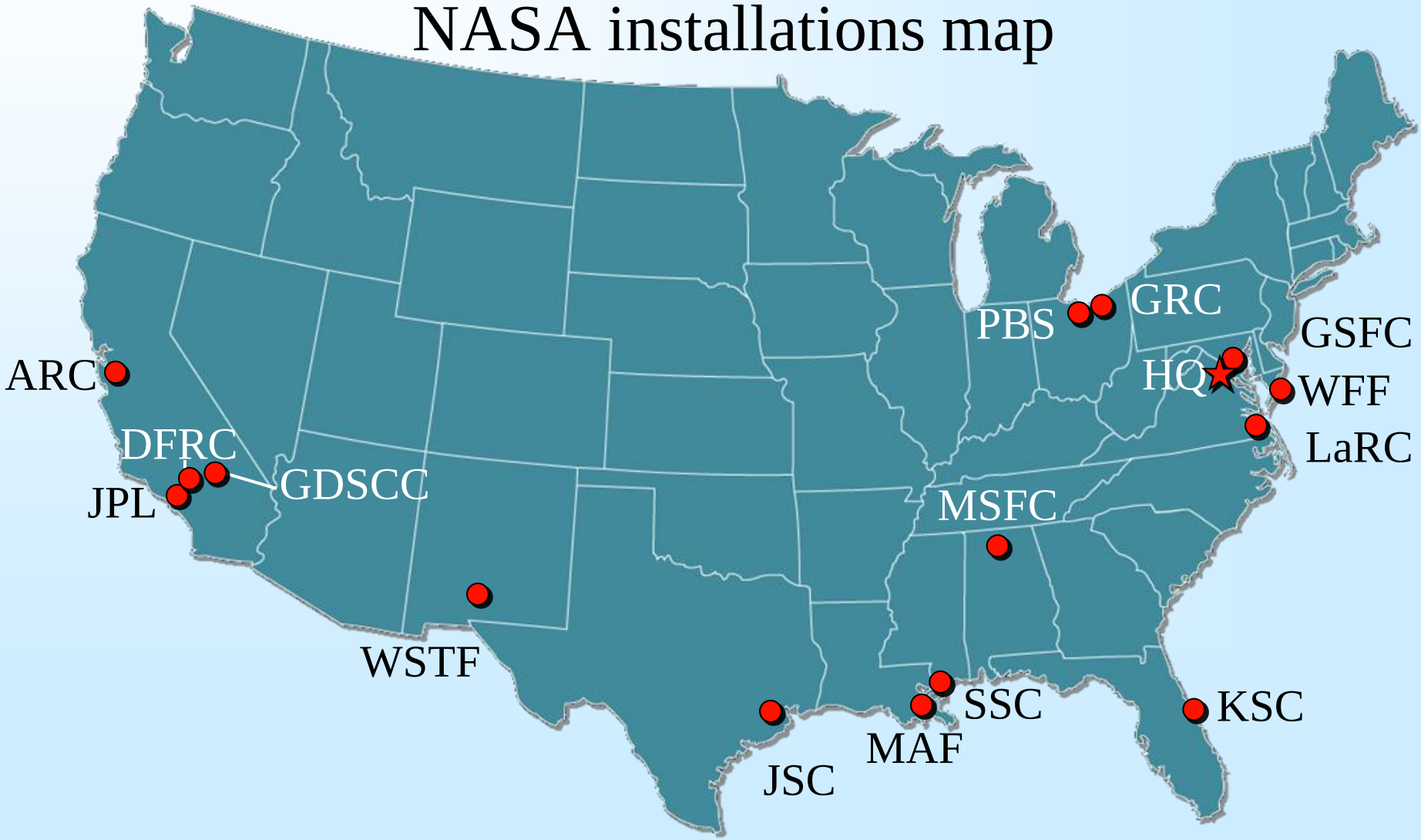
6.0 Site Summaries

- 6.0 Individual Site Summaries
  - Types of projects
    - Electricity producing
      - Dependent on incentives to compete with grid
        - » Exception: GSFC LFG CHP
      - Financial performance typically improves with scale
      - Modeled PV as 1 MW PPA
    - Thermal
      - Scale typically limited specific to niche application
      - Too small to access incentives
      - Lower capital and risk

6.0 Site Summaries



6.0 Site Summaries

- 6.1 GSFC-GB
  - GSHP not cost-effective alternative for steam line replacement in particular case evaluated
  - CHP with natural gas and cheap LFG blend economically viable without private ownership
    - Recommend consider PPA or Design-Build-Own Operate-Maintain (DBOOM) to leverage ITC & rapid depreciation
- 6.2 JSC
  - Solar thermal water heating at Sonny Carter Training Facility largest & best economics of solar thermal
    - Recommend validate capital and consider DBOOM/PPA

6.0 Site Summaries

- 6.3 MSFC
  - Waste-to-steam price unlikely to drop enough to support expanding use of steam
    - Recommend determine maximum steam price that would enable economic micro steam turbine, then explore potential for procurement at that price
  - PV lighting off-grid avoids high trenching costs
    - Recommend validate costs
- 6.4 KSC
  - Solar thermal water heating marginal ROI
  - PV PPA potential

6.0 Site Summaries

- 6.5 LaRC
  - GSHP viable in new construction/major renovation
    - Recommend evaluate gas furnaces and air conditioners
  - Waste-to-steam electricity project uncertain to compete with cheap grid electricity
    - Recommend consider exploring alternate waste disposal options with county to determine impacts on economics
  - For PV, recommend monitor state regulations in case voluntary RPS becomes requirement
- 6.6 MSFC-MAF
  - Solar thermal water heating not economical

6.0 Site Summaries

- 6.7 GSFC-WFF
  - Two wind turbines unlikely to recover cost
  - GSHP near harsh beach conditions weak economics but improves reliability
  - For PV, recommend monitor state regulations in case voluntary RPS becomes requirement
- 6.8 SSC
  - Recommend evaluate feasibility of recovering and reusing $1.5 M/year waste hydrogen
  - Third best solar thermal water heating economics in assessment

6.0 Site Summaries

- 6.9 DFRC
  - At Edwards Air Force Base, solar thermal air heating project reasonable economics
  - At Palmdale, PV PPA potential
- 6.10 JPL
  - Solar thermal water heating weak economics
  - PV PPA potential, but higher than average installed cost due to small systems on multiple roofs
- 6.11 JPL-GDSCC
  - PV PPA potential

6.0 Site Summaries

- 6.12 GRC
  - Solar thermal air heating weak economics but low risk
- 6.13 JSC-WSTF
  - Power export constraints preclude utility scale
  - Second best solar thermal water heating economics in assessment
  - PV PPA potential

6.0 Site Summaries

- 6.14 GRC-PBS
  - Wind resource DOE lab estimate appears utility-scale developable; not yet proven by meteorological study
  - For PV, recommend monitor state solar REC market in case value supports PV project
- 6.15 ARC
  - Solar thermal water heating not cost effective

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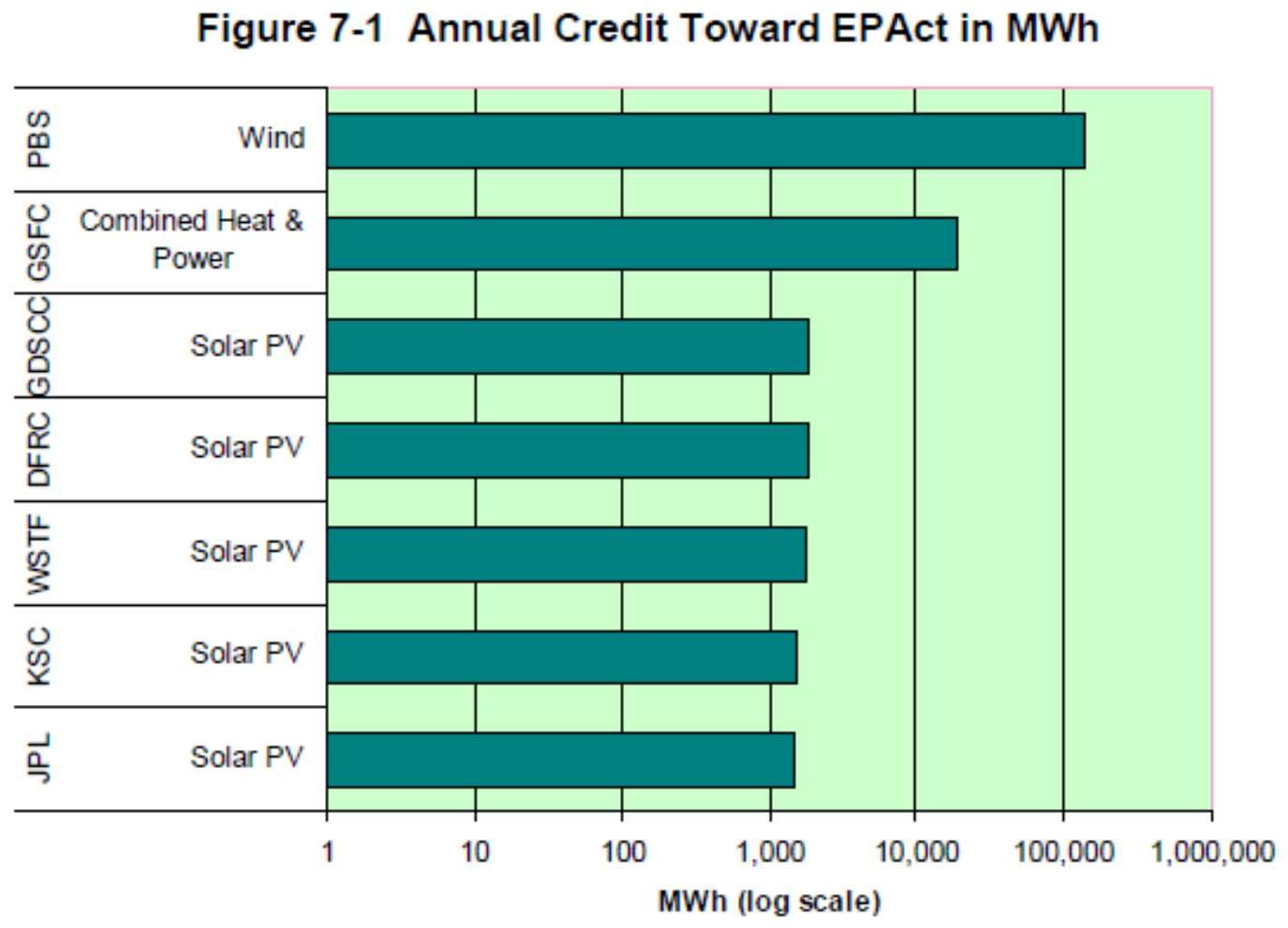
7.0 Summary & Ranking

- 7.1 Ranking by Metrics
  - Figures of electricity producing and non-electricity producing renewable energy contribution

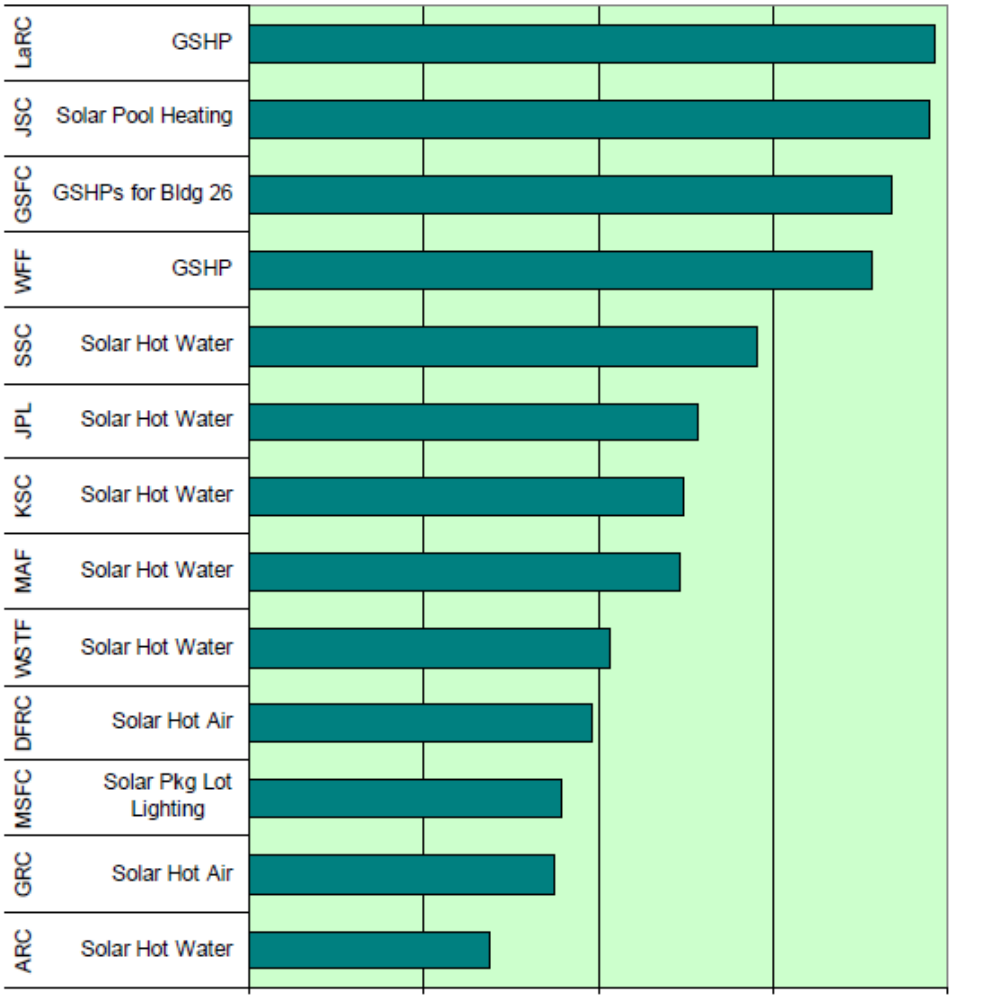
7.0 Summary & Ranking

7.1 Ranking by Metrics (continued)



7.0 Summary & Ranking

Figure 7-2 Annual Renewable Energy Production of Non-EPAct Projects (MMBtu)



7.0 Summary & Ranking

- 7.1 Ranking by Metrics (continued)
  - Rank order determined for each metric; lowest best
  - Summed rank order for overall ranking; lowest best
  - Table of rank order by metrics

7.0 Summary & Ranking

Table 7-1 Overall Ranking by Metrics

SITE	NO.	PROJECT NAME	Ann Credit towards EPACT	Ann Renewable Energy as % Agency Wide[a]	IRR	Clear Path Fwd	Overall Rank
GSFC	1	Combined Heat & Power	18,822	1.02%	19.7%	2	1
PBS	19	Wind	137,800	7.44%	14.7%	3	2
DFRC	11	Solar PV	1,812	0.10%	6.5%	2	3
JSC	3	SCTF Solar Pool Heating	0	0.04%	12.8%	1	4
LaRC	7	GSHP	0	0.04%	11.3%	1	5
KSC	5	Solar PV	1,526	0.08%	6.6%	2	6
GDSCC	15	Solar PV	1,830	0.10%	4.3%	2	7
SSC	10	Solar Hot Water	0	0.00%	9.2%	2	8
WSTF	17	Solar PV	1,782	0.10%	3.2%	2	9
DFRC	12	Solar Hot Air	0	0.00%	11.2%	2	10
WSTF	18	Solar Hot Water	0	0.00%	9.8%	2	11
JPL	13	Solar PV	1,479	0.08%	4.1%	2	12
MSFC	4	Solar Pkng Lot Lighting[b]	5	0.00%		1	13
WFF	9	GSHP	0	0.02%	5.3%	3	14
KSC	6	Solar Hot Water	0	0.00%	6.2%	2	15
JPL	14	Solar Hot Water	0	0.00%	4.7%	2	16
GSFC	2	GSHPs for Bldg 26	0	0.02%	-1.7%	1	17
MAF	8	Solar Hot Water	0	0.00%	4.4%	2	18
GRC	16	Solar Hot Air	0	0.00%	5.1%	1	19
ARC	20	Solar Hot Water	0	0.00%	-6.1%	3	20

7.0 Summary & Ranking

- 7.2 Project Financial Performance Relative to Renewable Energy Production and Project Scale
  - Table of financial indicators by project
  - Figure of financial performance, production, and capital investment

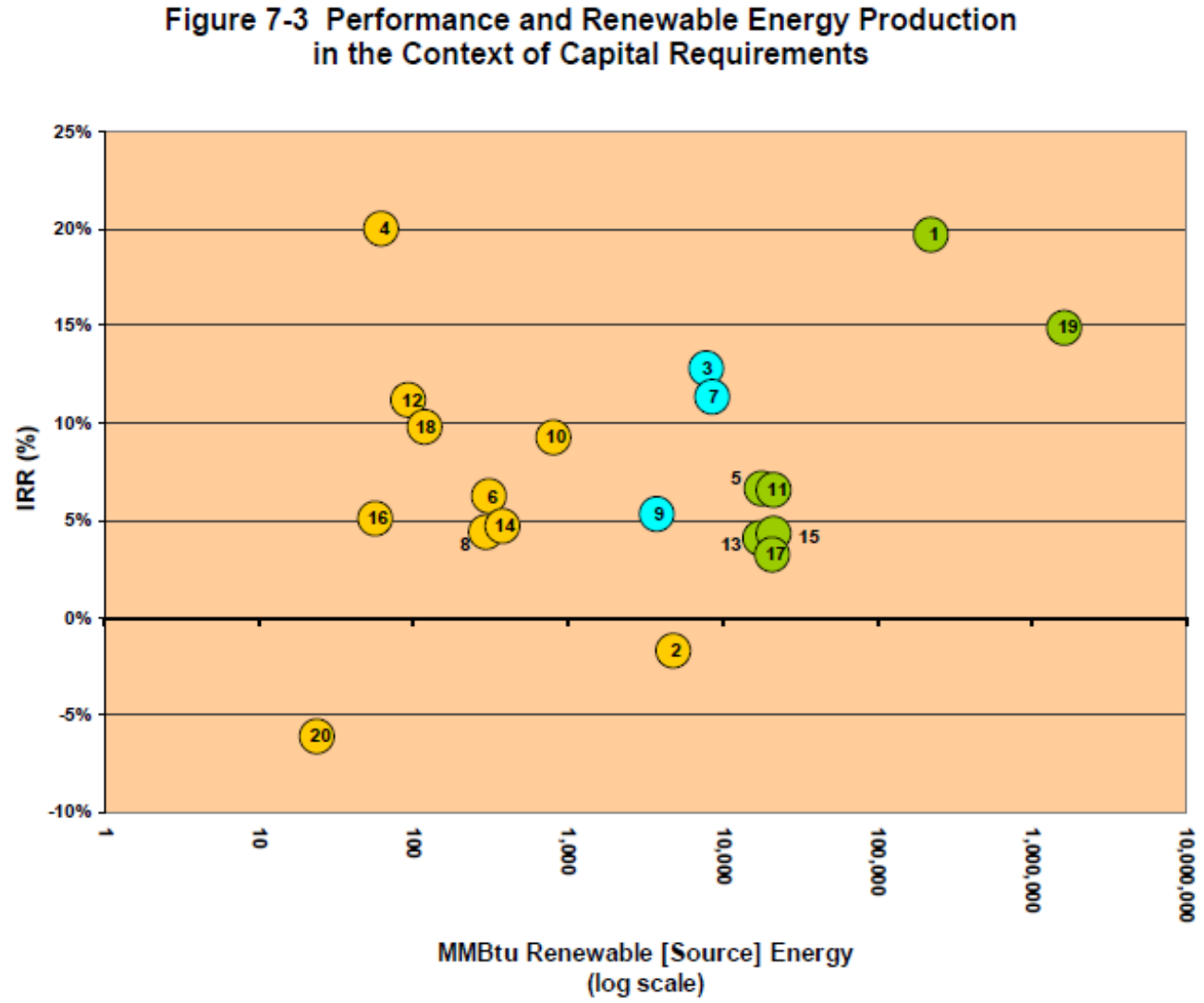
7.0 Summary & Ranking

Table 7-2 Financial Indicators by Project

Site	No.	Project Name	IRR	NPV	Capital Cost
GSFC	1.	CHP	19.7%	$21,911,715	$10,407,600
GSFC	2.	GSHPs for Bldg 26[a]	(1.7%)	$299,776	($484,644)
JSC	3.	SCTF Solar Pool Heating	12.8%	$1,518,682	$1,210,083
MSFC	4.	Solar Pkg Lot Lighting[a]	+[b]	$11,517	($7,200)
KSC	5.	Solar PV	6.6%	$869,412	$8,252,460
KSC	6.	Solar Hot Water	6.2%	$10,151	$66,982
LaRC	7.	GSHP	11.3%	$500,717	$510,866
MAF	8.	Solar Hot Water	4.4%	($3,468)	$62,632
WFF	9.	GSHP	5.3%	$11,593	$234,498
SSC	10.	Solar Hot Water	9.2%	$50,983	$82,648
DFRC	11.	Solar PV	6.5%	$856,538	$8,796,900
DFRC	12.	Solar Hot Air	11.2%	$11,115	$10,516
JPL	13.	Solar PV	4.1%	($272,815)	$6,888,000
JPL	14.	Solar Hot Water	4.7%	($1,330)	$69,578
GDSCC	15.	Solar PV	4.3%	($264,905)	$8,532,972
GRC	16.	Solar Hot Air	5.1%	$203	$8,413
WSTF	17.	Solar PV	3.2%	($875,454)	$8,532,972
WSTF	18.	Solar Hot Water	9.8%	$25,595	$39,362
PBS	19.	Wind	14.7%	$27,951,782	$95,725,300
ARC	20.	Solar Hot Water	(6.1%)	(24,039)	$29,253

7.0 Summary & Ranking

Figure 7-3 Performance and Renewable Energy Production in the Context of Capital Requirements



capital: ● < $100K, ● $100K to $1.5M, ● > $1.5M

7.0 Summary & Ranking

- 7.3 Projects Contributing to EPAct Goals
  - 7 potential projects using 3 electricity technologies

Table 7-3 EPAct Applicable Technologies by Site

Resource	Technology	GSFC	JSC	MSFC	KSC	LaRC	MAF	WFF	SSC	DFRC	JPL	GDSCC	GRC	WSTF	PBS	ARC	Total
Wind	Turbines														■		1
Solar	Photovoltaic				■					■	■	■		■			5
Bio	Co/Generation w/ gas/liquid/solid	■															1
Bio	Municipal Solid Waste																0
Solar	Concentrating Thermo-electric																0
Hydro	Low-impact																0
Geo	Geothermal Electric																0

7.0 Summary & Ranking

- 7.3 Projects Contributing to EPAct Goals (cont'd)
  - Key factors
    - Wind
      - PTC
      - Quality of wind resource
      - Scale (1 to 4 turbines virtually impossible economics)
        - » Large land area
        - » Access for heavy equipment
        - » Ability to export power
        - » Away from radar

7.0 Summary & Ranking

- 7.3 Projects Contributing to EPAct Goals
  - Key factors (continued)
    - PV entirely incentive dependent; evaluated in states with existing or emerging REC market
    - CHP with biofuel
      - Central steam plant
      - Substantial year-round requirement for thermal energy that coincides with electrical energy requirements
      - "Spark spread": biofuel cost low compared to electricity
        - » Electric rates below $0.07 should not be considered
    - Waste to energy depends on collaboration for supply

7.0 Summary & Ranking

- 7.3 Projects Contributing to EPAct Goals
  - Key factors (continued)
    - Concentrating solar thermal electricity
      - Solar resource
      - Land
      - Ability to export power
    - Micro hydro
      - Water resource with substantial perennial flow plus significant head pressure
    - Geothermal electricity
      - High-quality geothermal resource
      - Ability to export power

7.0 Summary & Ranking

- 7.4 Discussion
  - Recommend drop bottom 5 projects
    - Do not produce renewable electricity
    - Very small and/or negative ROI
    - Not NASA's best opportunities
  - Remaining 15 fall into groups
    - Large, more certainty
    - Large, less certainty
    - Small to medium, more certainty

7.0 Summary & Ranking

7.4 Discussion (continued)

Table 7-4 Project Summary by Investment Level

Project No.	Project Rank	Description	Comments
Large Projects – More Certainty			
1.	1	GSFC CHP	
11.	3	DFRC Solar PV	
13.	12	JPL Solar PV	
15.	7	GDSCC Solar PV	
17.	9	WSTF Solar PV	
Large Projects - Less Certainty			
19.	2	PBS Wind	Wind resource has not been confirmed.
6.	15	KSC Solar PV	State RPS has not yet materialized.

- Recommend GSFC CHP stands out with strong financials and dispatchable power
- Recommend focus PV where NASA purchases grid electricity directly from utility; consider bundling

7.0 Summary & Ranking

7.4 Discussion (continued)

Table 7-4 Project Summary by Investment Level

Project No.	Project Rank	Description	Comments
Small to Medium Projects - More Certainty			
3.	4	JSC SCTF Solar Pool Heating	
7.	5	LaRC GSHP	
10.	8	SSC Solar Hot Water	
12.	10	DFRC Solar Hot Air	
18.	11	WSTF Solar Hot Water	
4.	13	MSFC Solar Parking Lot Lighting	
5.	6	KSC Solar Hot Water	
9.	14	WFF GSHPs	Very long cost recovery period, uncertainty regarding capital and savings

- JSC solar thermal water heating best economics in group but vulnerable to capital costs

Agenda

- 1.0 Background
- 2.0 Introduction
- 3.0 Consistency
- 4.0 RETScreen Software
- 5.0 Project Metrics
- 6.0 Site Summaries
- 7.0 Summary & Ranking
- 8.0 Path Forward

8.0 Path Forward

8.0 Path Forward

- Recommend institutionalizing process for project identification, development, and execution to implement best projects in most efficient and least-cost manner
  - Validate resource and characterize project
    - Location and land area available for development
    - Maximum potential energy production
    - Constraints on utilization of energy (i.e. uses for thermal or mechanical energy)
    - Expected energy production and order of magnitude cost

8.0 Path Forward

8.0 Path Forward

- Recommend institutionalizing process…(continued)
  - Follow likely pathway based on capital and production
    - Tier I: Small to medium thermal or mechanical projects or "demonstration scale" electrical projects
      - » Goal: Validate economics to justify appropriated funds
      - » Too small to attract third-party project owners seeking to capture tax benefits for renewables
      - » Likely traditional development and funding through appropriations, UESC/ESPC, or EUL

8.0 Path Forward

8.0 Path Forward

- Follow likely pathway…(continued)
  - Tier II: Behind the meter renewable electric projects or large-scale thermal projects
    - » Goal: Validate economics to attract private developers and negotiate favorably
    - » Ownership by taxable entity essential to leverage significant tax benefits; PV PPA, non-PV DBOOM
    - » NASA's best opportunities because standalone basis, no NASA capital, and major goal contributions
    - » Rule: Payback <5 years to obtain private equity
    - » Key: Resolve procurement constraints

8.0 Path Forward

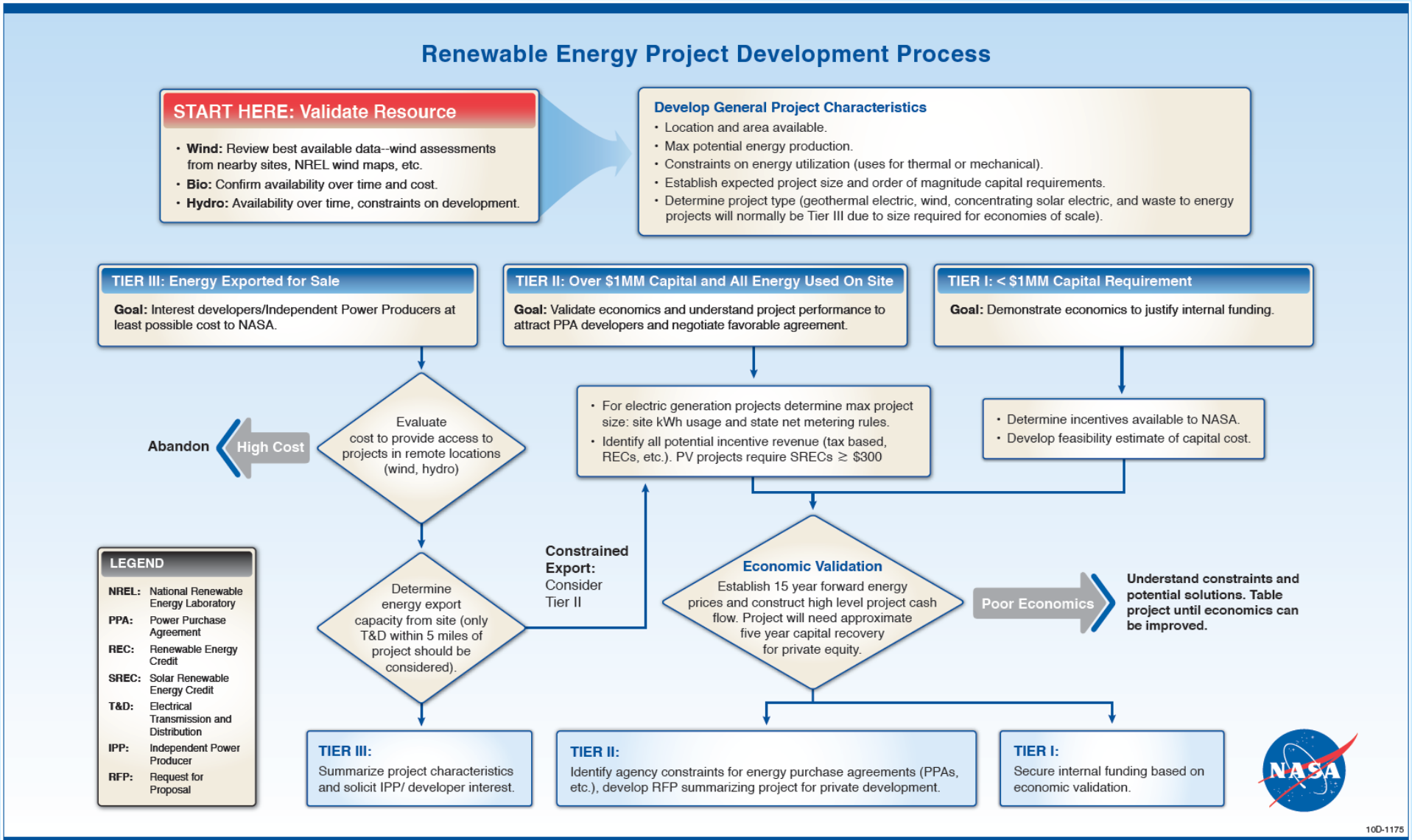
- 8.0 Path Forward
  - Follow likely pathway…(continued)
    - For Tier I and II, validating economics includes developing data:
      - Site energy usage
      - Forward energy costs
      - State net metering rules
      - Project specific incentives
      - More refined estimate of capital cost

8.0 Path Forward

8.0 Path Forward

- Follow likely pathway…(continued)
  - Tier III: Utility-scale electric projects that enable Independent Power Producer to export power to grid
    - » Goal: At least possible cost to NASA, garner interest from developers to continue project development process with private equity
    - » Determine road access and power export constraints; rule: transmission within 5 miles of site
    - » Large capital investment dictates expensive feasibility diligence; understand minimum prefeasibility diligence required from NASA to obtain capital commitment

8.0 Path Forward



8.0 Path Forward

- 8.1 Approaches to Implementation for Type I Projects

Table 8-1 Funding Options for Type I REA Projects

(Projects shown in rank order)

No.	Site	Project	Capital Cost	Funding Options		
				Avoided Cost	NASA Capital	UESC/ESPC
4.	MSFC	Solar Pkg Lot Lighting	($7,200)			
7.	LARC	GSHP	$510,866			
3.	JSC	SCTF Solar Pool Heating	$1,210,083			
16.	GRC	Solar Hot Air	$8,413			
12.	DFRC	Solar Hot Air	$10,516			
2.	GSFC	GSHPs For Bldg 26	($484,644)			
18.	WSTF	Solar Hot Water	$39,362			
6.	KSC	Solar Hot Water	$66,982			
10.	SSC	Solar Hot Water	$82,648			
8.	MAF	Solar Hot Water	$62,632			
14.	JPL	Solar Hot Water	$69,578			
9.	WFF	GSHP	$234,498			
20.	ARC	Solar Hot Water	$29,253			

8.0 Path Forward

- 81. Approaches…for Type I Projects (cont'd)
  - Recommend incorporate in construction/renovation
- 8.2 Type II Project Implementation: Behind the Meter
  - PPA most common financing structure
    - Typically 15 years contract length
      - Presenter's note: challenging for Federal sites to exceed 10 years
    - DOE info
      - http://www1.eere.energy.gov/femp/financing/power_purchase_agreements.html

8.0 Path Forward

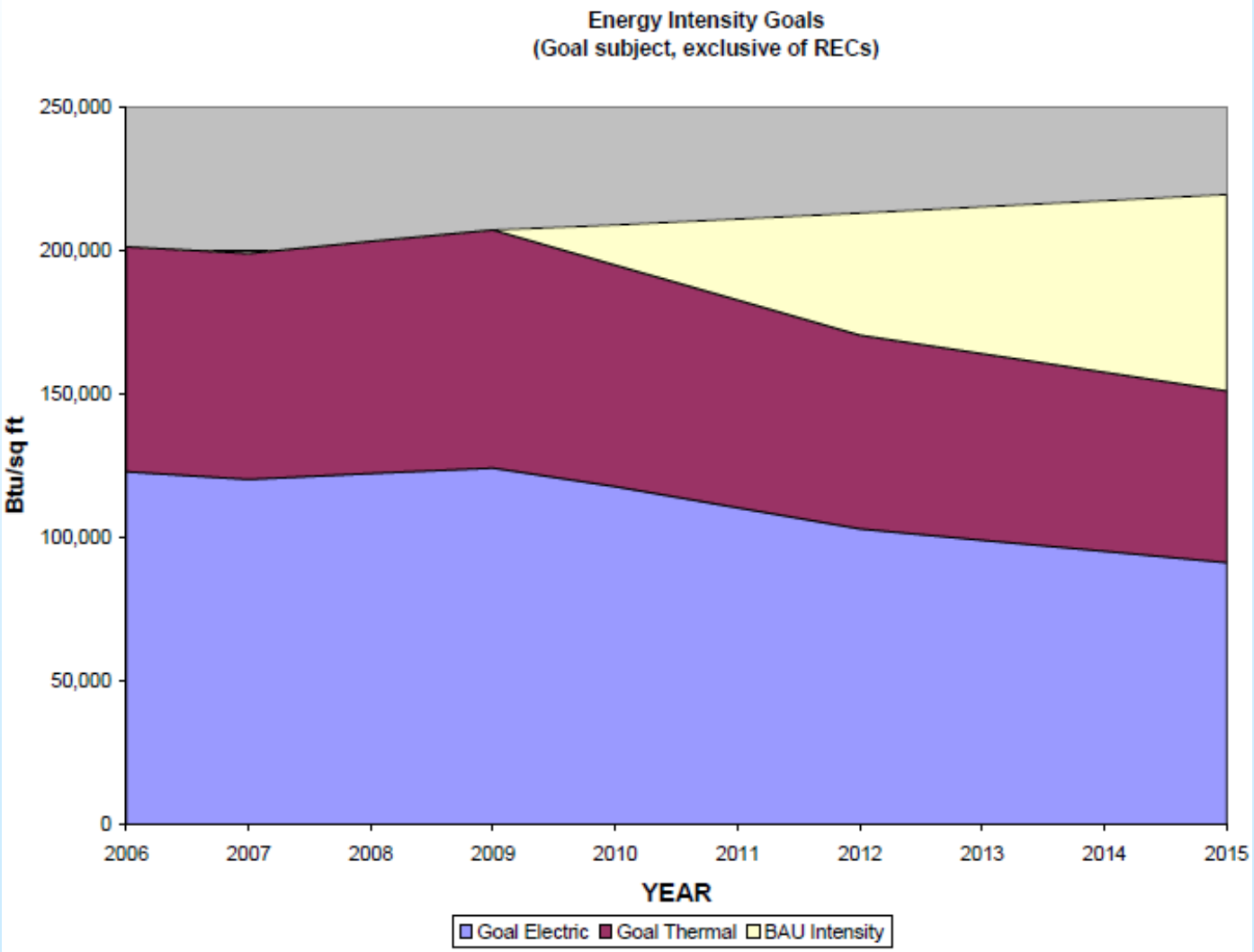
- 8.3 Type III Renewable Projects: Utility Scale
  - Recommend negotiate compensation considering EPAct 2005
    - Electricity and RECs could allow EPAct credit with bonus
      - Presenter's note: Restoring EUL in-kind consideration appears key

8.0 Path Forward

- 8.4 Meeting EPAct Goals
  - Meeting energy intensity requirement decreases amount of renewable energy needed for compliance
    - Illustrated by two figures

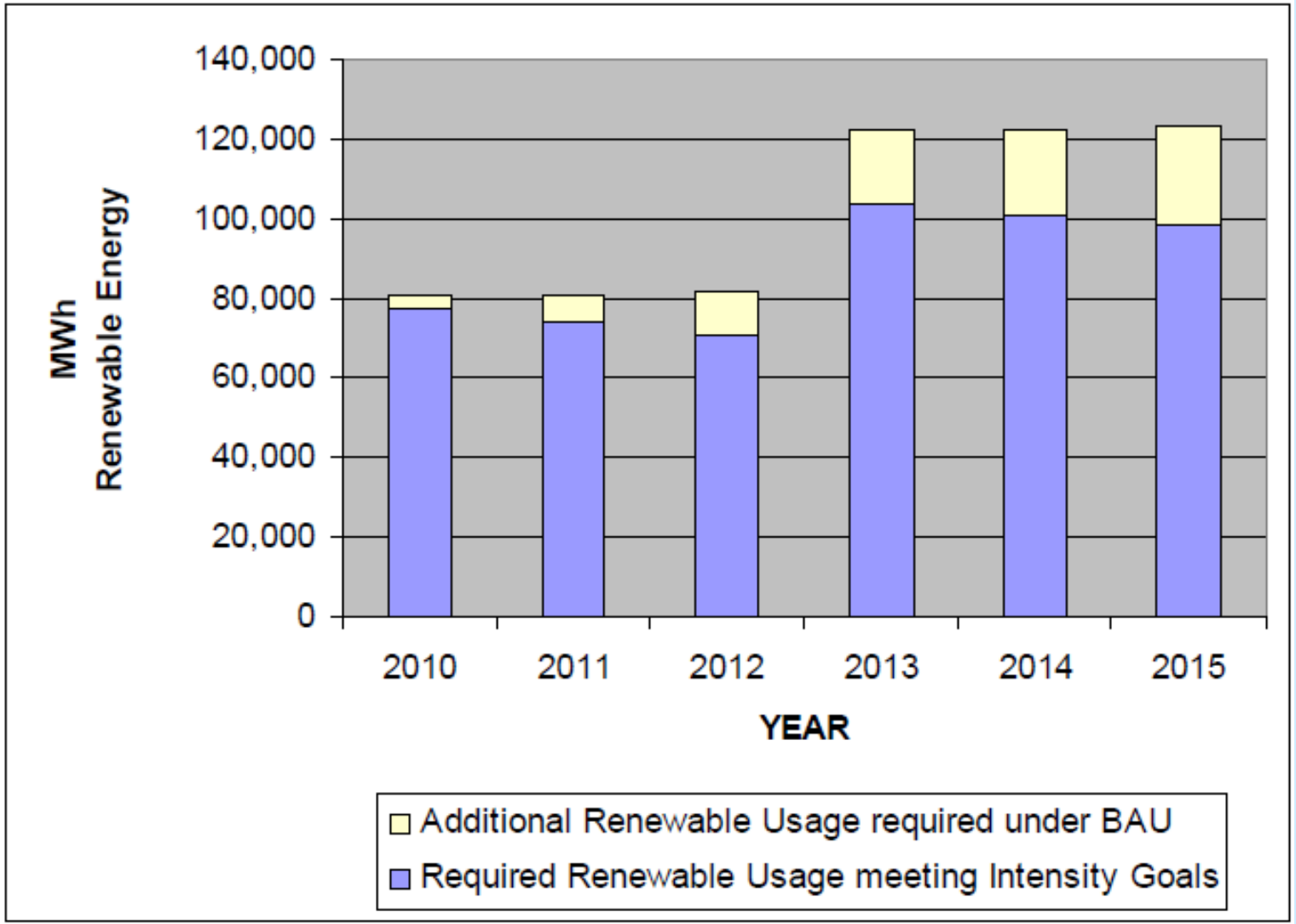
8.0 Path Forward

Figure 8-1 Projected and Goal Compliant Energy Intensity Paths



8.0 Path Forward

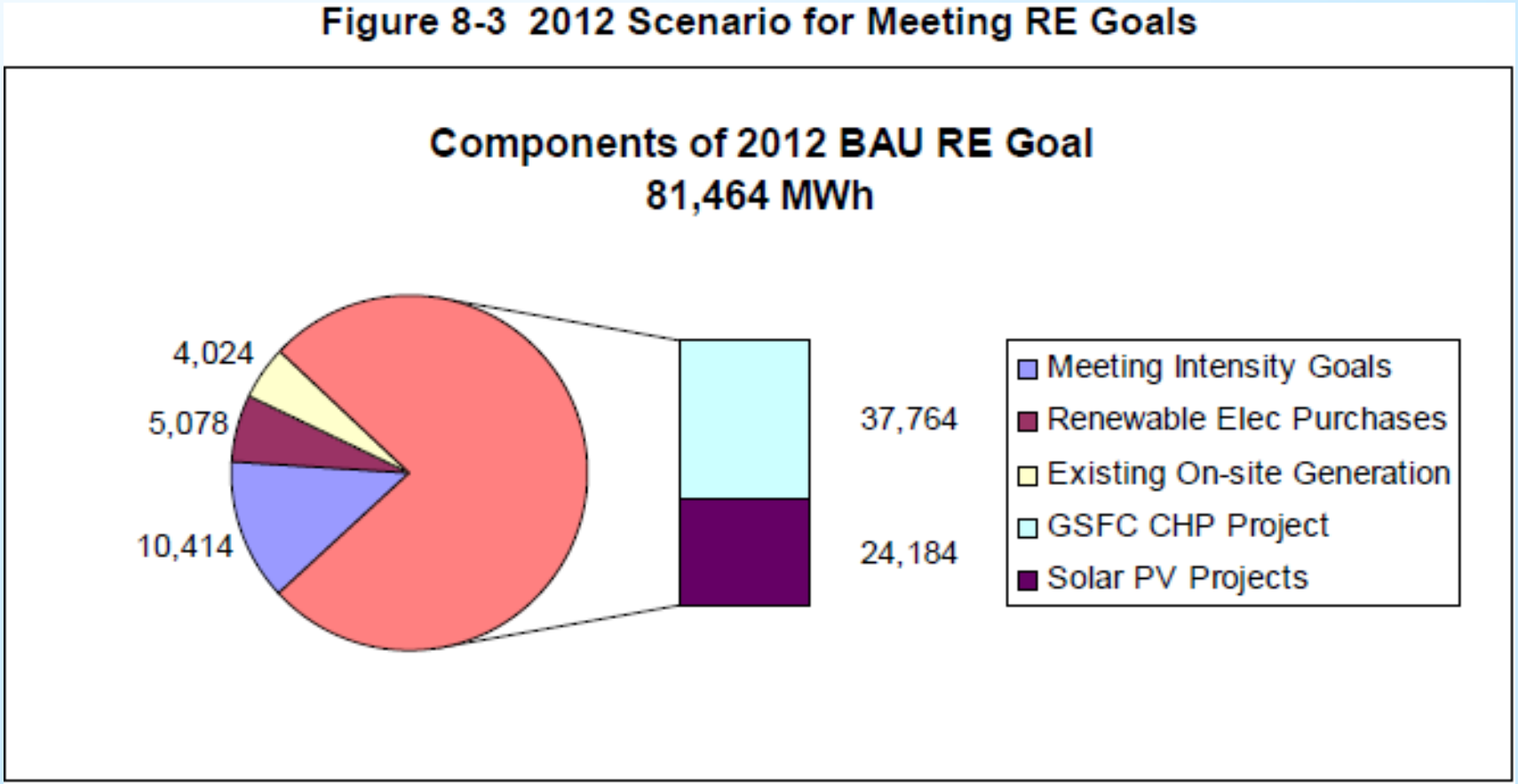
Figure 8-2 Impact of Energy Intensity on Renewable Energy Requirements



8.0 Path Forward

- 8.4 Meeting EPAct Goals (continued)
  - Exploring solutions mix to meet renewable goal

Figure 8-3 2012 Scenario for Meeting RE Goals



8.0 Path Forward

- 8.5 Institutional Barriers
  - Goals currently pushed out to site level; lack formal agency-wide approach
  - Site energy managers often lack technical and financial know-how to screen renewable potential
  - Lack systematic approach to project development
  - Need Agency guidance for navigating Federal acquisition regulations on financing approaches
  - Need standardized approach for evaluating project financial performance in order to direct effort to most promising opportunities

8.0 Path Forward

- 8.6 The GHG Reporting Rule and EO 13514
  - Renewable energy projects contribute to meeting greenhouse gas (GHG) emission reduction requirements
    - Different impact for Environmental Protection Agency GHG Reporting Rule versus EO 13514
    - Table of impacts by project

8.0 Path Forward

Table 8-2 GHG Impact of Projects in the REA

No	Site	Project Name	EPA GHG Reduction?	Metric Ton EO GHG Reduction
1.	GSFC	CHP[a]	No	5,861
2.	GSFC	GSHPs for Bldg 26[b]	Yes	N/A
3.	JSC	SCTF Solar Pool Heating	Yes	411
4.	MSFC	Solar Pkg Lot Lighting	No	3
5.	KSC	Solar PV	No	913
6.	KSC	Solar Hot Water	Yes	16
7.	LaRC	GSHP[b]	Yes	N/A
8.	MAF	Solar Hot Water	Yes	15
9.	WFF	GSHP[b]	Yes	N/A
10.	SSC	Solar Hot Water	No	32
11.	DFRC	Solar PV[c]	No	610
12.	DFRC	Solar Hot Air	Yes	5
13.	JPL	Solar PV[c]	No	498
14.	JPL	Solar Hot Water	Yes	19
15.	GDSCC	Solar PV[c]	No	616
16.	GRC	Solar Hot Air	Yes	3
17.	WSTF	Solar PV[c]	No	1,340
18.	WSTF	Solar Hot Water	No	21
19.	PBS	Wind[d]	No	7,000
20.	ARC	Solar Hot Water	No	2